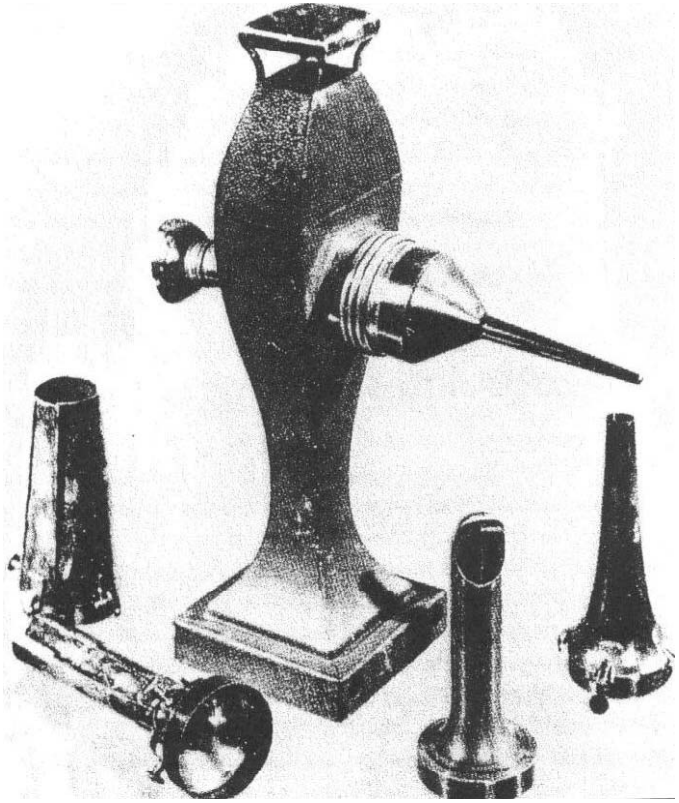
Endoscopic Imaging

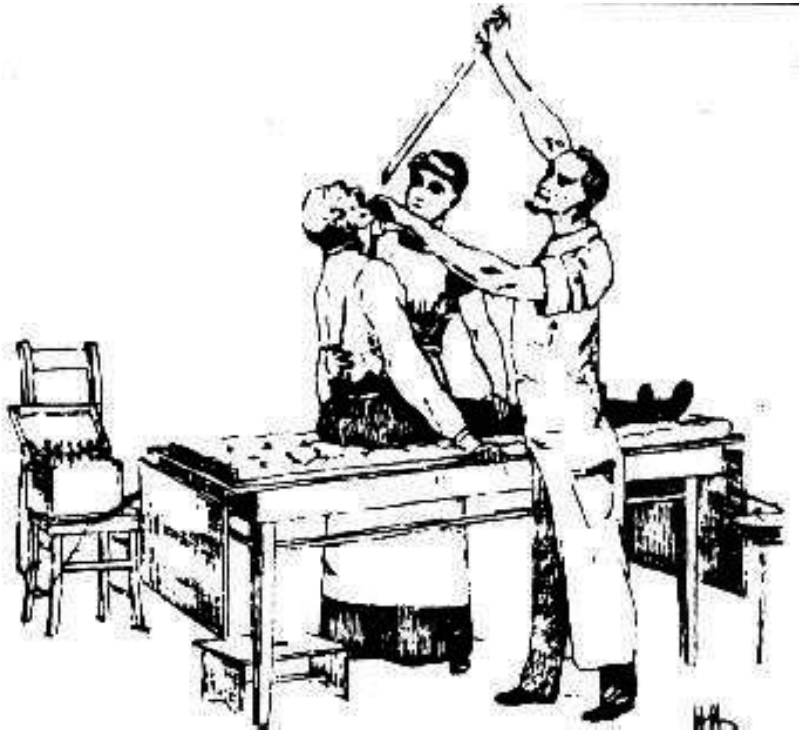
History of Endoscopy

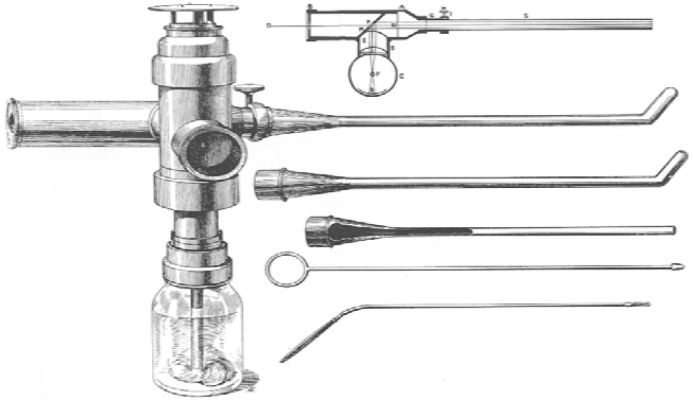
- **400 BC: Hippocrates observes the anus using a speculum**
- **The first real endoscope that was developed was made by Phillip Bozzini in 1805 to examine the urethra, the bladder and vagina.**



History of Endoscopy

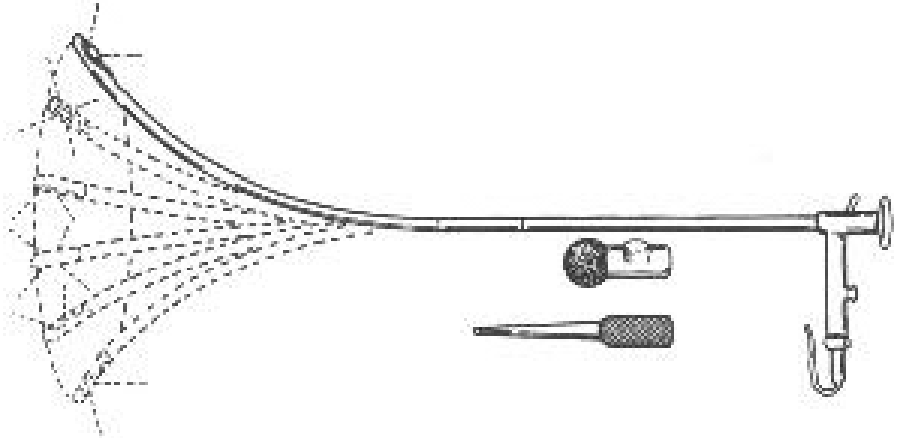
- 1867 Desormeaux used an open tube to examine the genitourinary tract
- Adolf Kussmaul in 1868 used a straight rigid metal tube over a flexible obturator to perform the first gastroscopy.





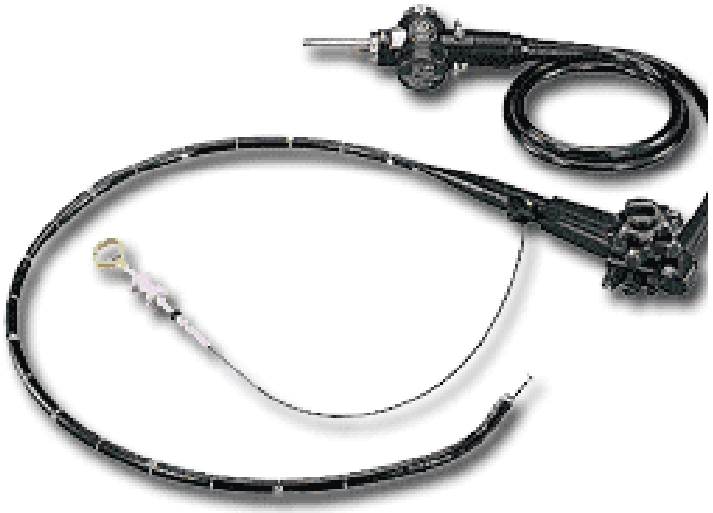
History of Endoscopy

- **Building on the work of others, Rudolph Schindler constructed the first practical gastroscope in 1932.**



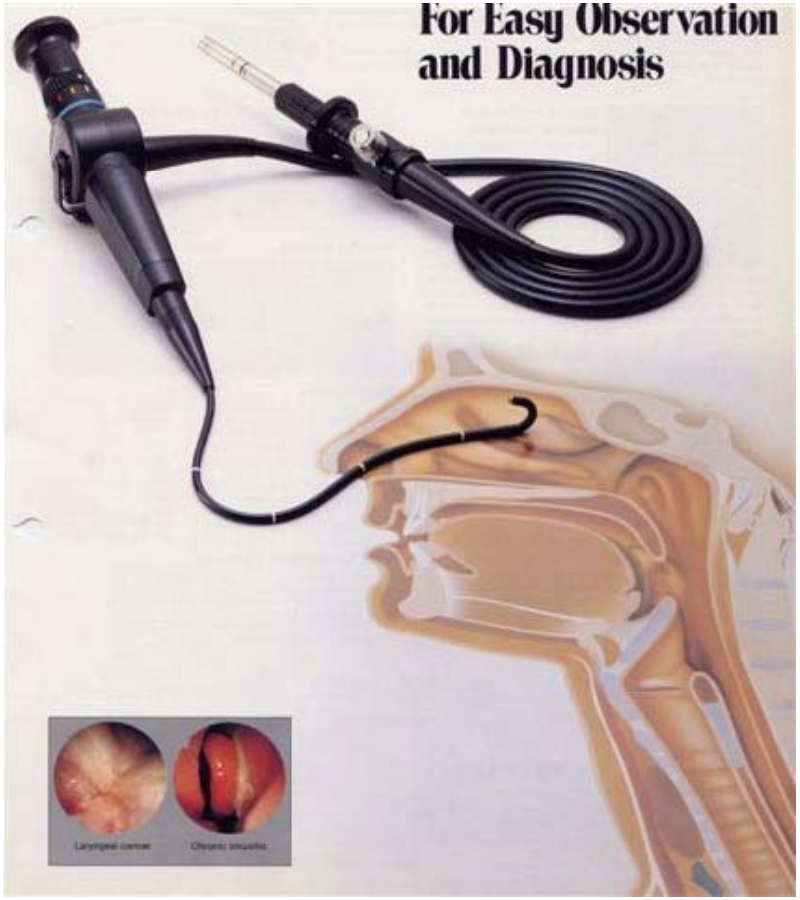
History of Endoscopy

- **In 1957 Basil Hirschowitz developed his prototype fiberscope.**



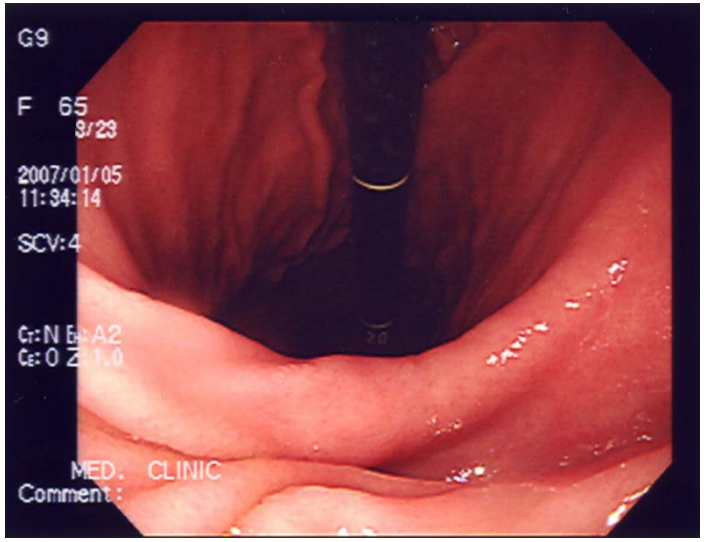
Endoscopy

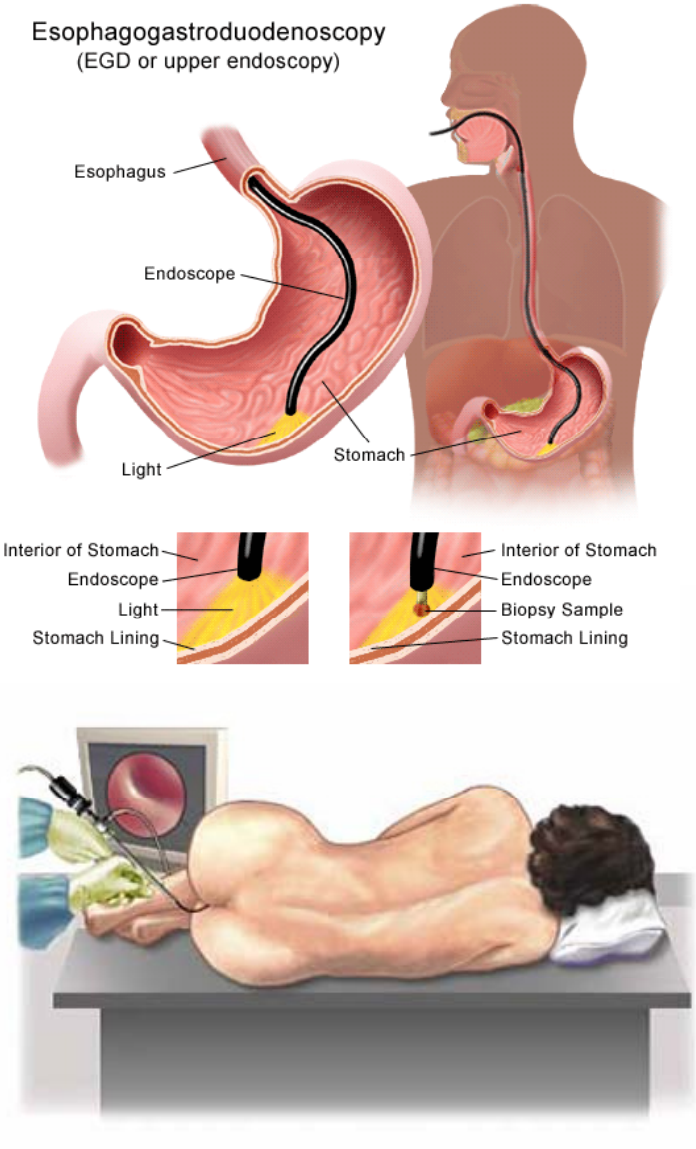
- **Endoscopy**
  - A minimally invasive diagnostic medical procedure
  - The examination of internal body cavities using a specialized medical instrument called an endoscope.
  - Gives visual evidence of the problem (e.g. cancer, ulceration or inflammation)
  - Can be used to collect a sample of tissue or remove problematic tissue
  - Used to take photograph of the hollow internal organs
  - Performed under
    - Conscious sedation
    - Total Anesthesia



Endoscopy

- Physicians use endoscopy to diagnose, monitor, and surgically treat various medical problems
- A surgeon introduces the endoscope into the body either through a body opening, such as the mouth or the anus, or through a small incision in the skin.





Endoscopy

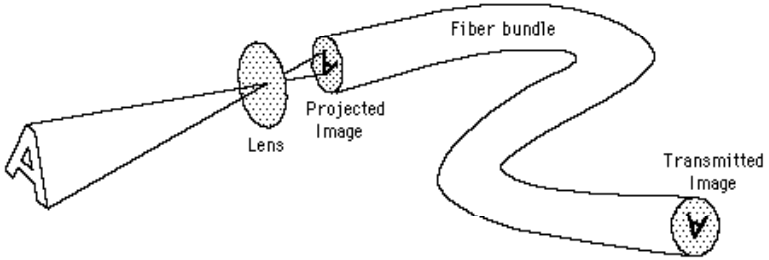
- **Risks of Endoscopy**
  - Sedation
  - Damage to dentition
  - Aspiration
  - Perforation or hemorrhage after endoscopic dilatation
  - Perforation, infection, and aspiration after percutanous endoscopic gastrostomy insertion
  - Perforation or hemorrhage after flexible sigmoidoscopy / colonoscopy with polypectomy
  - Pancreatitis, cholangitis, perforation or bleeding after ERCP

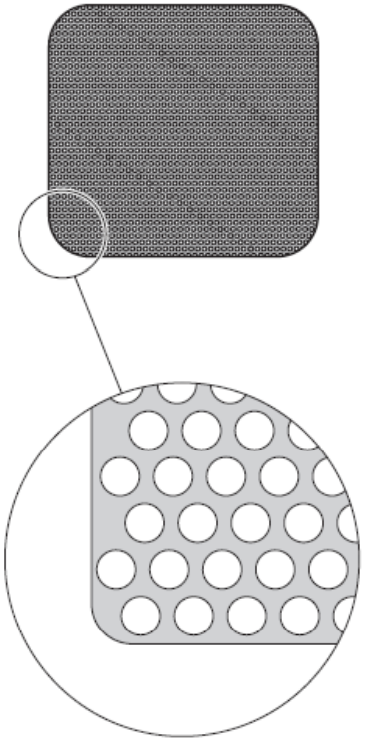
Endoscopy

- **The endoscope**
  - A slender, flexible or rigid tube
  - Equipped with lenses and a light source.
  - CCDs are used to feed a video to the monitor
  - Through the accessory channels of the endoscope water and air is supplied to wash and dry the surgical site.
  - Also has a channel through which surgeons can manipulate tiny instruments, such as forceps, surgical scissors, and suction devices.
    - A variety of instruments can be fitted to the endoscope for different purposes.

The Flexible Endoscope

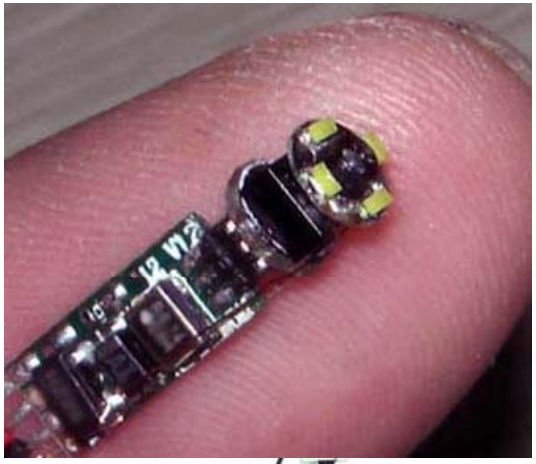
- **Fiberoptic instruments**
  - Based on optical viewing bundles
  - 2–3·mm in diameter and contains 20·000–40·000 fine glass fibers, each close to 10·µm in diameter
  - Each individual glass fiber is coated with glass of a lower optical density to prevent leakage of light from within the fiber
    - The space between the fibers causes a dark 'packing fraction' → fine mesh frequently apparent in the fiberoptic image
  - Advantages
    - Fiberoptic bundles are extremely flexible, and an image can be transmitted even when tied in a knot.
    - Small diameter
    - Direct view (monitor not necessary)
  - Limitations
    - The image quality of a fibreoptic bundle, though excellent, can never equal that of a rigid lens system or a video-endoscope
      - Limited number of "pixels"





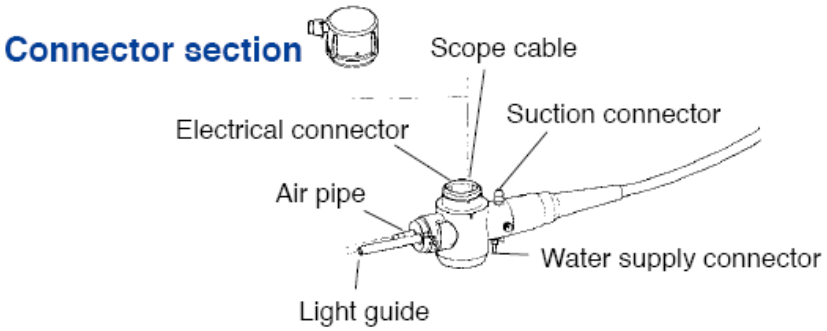
The Flexible Endoscope

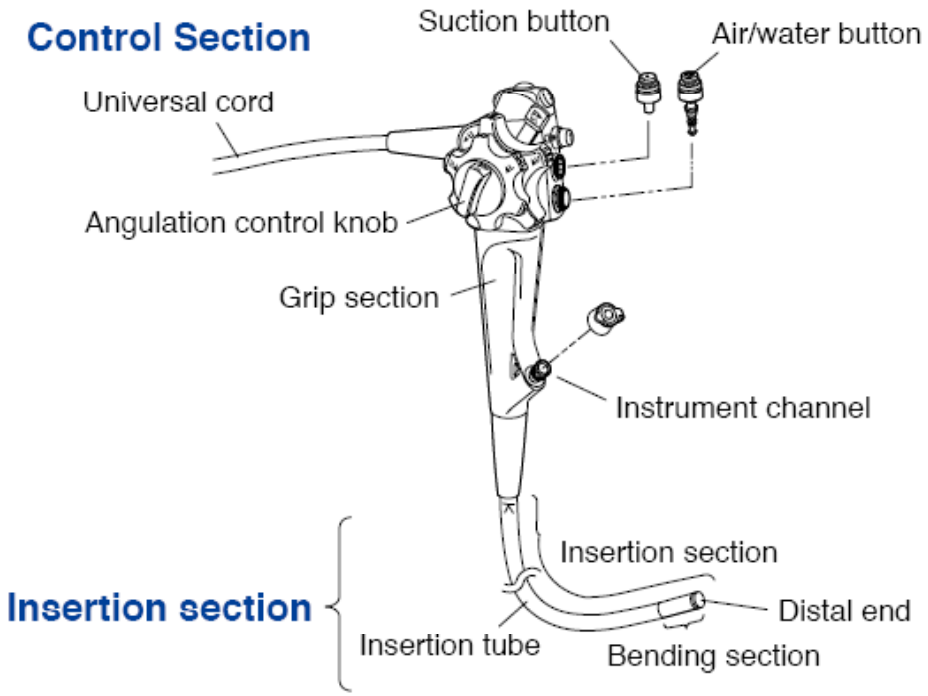
- **Video-endoscopes**
  - Mechanically similar to fiber-endoscopes,
  - A CCD chip and supporting electronics mounted at the tip
  - To and fro wiring replacing the optical bundle
  - Further electronics and switches occupying the site of the ocular lens on the upper part of the control head.
  - Advantages
    - Improved image quality
    - View through a monitor
      - Removing any need to hold the instrument close to the endoscopist's eye has hygienic advantages (avoidance of splash contamination)
      - Improved instrument design and handling techniques
  - Limitations
    - No direct viewing
    - Can not be made < 5 mm

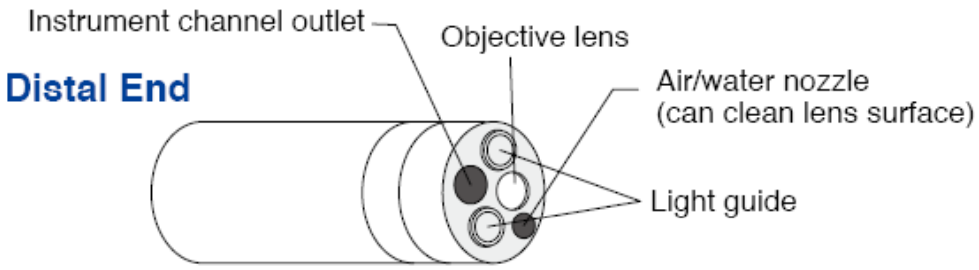


The Flexible Endoscope

- **Parts of the endoscope**
  - Connector Section
  - Control Section
  - Insertion Section

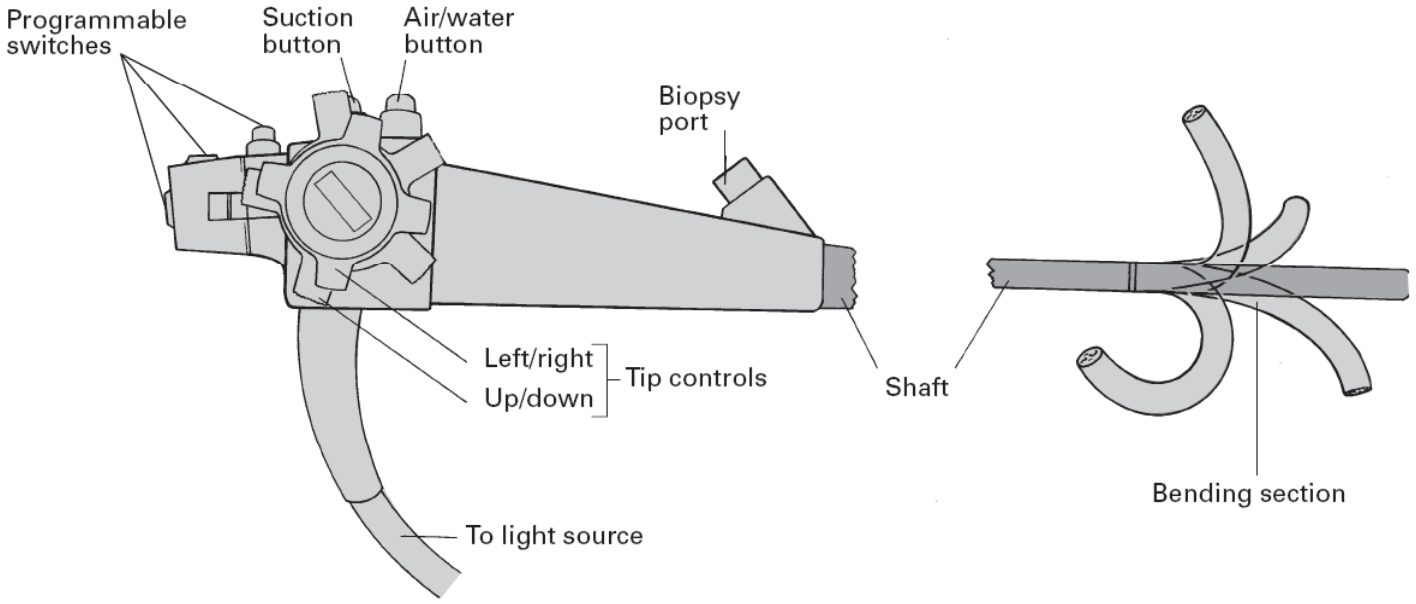






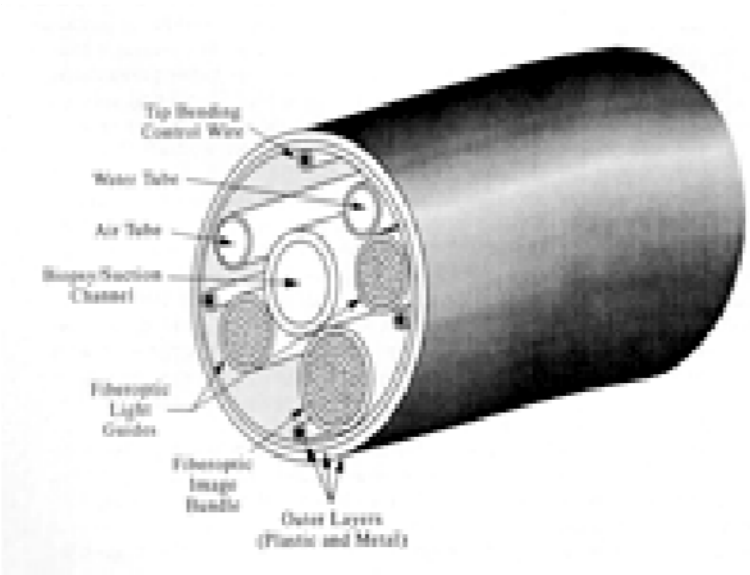
The Flexible Endoscope

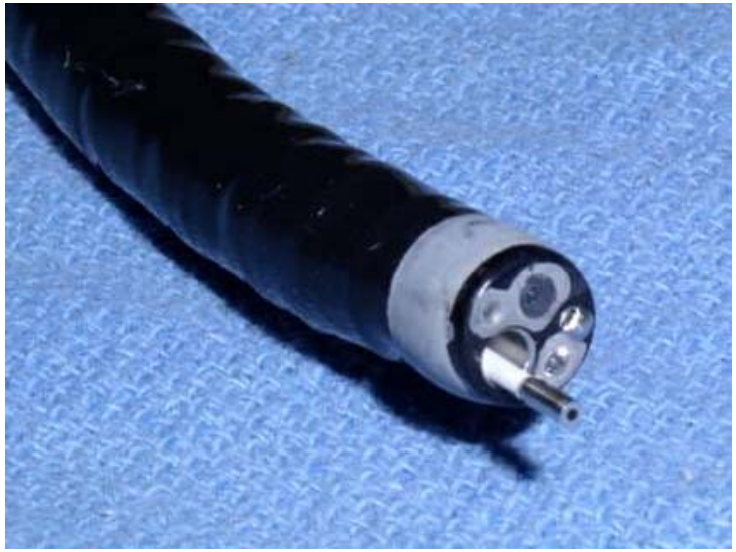
- **Control section**
  - Held in the operator's left hand
  - Has two stacked angulation control knobs
    - direct up/down and left/right deflection of the endoscope tip.
  - Has air/water and suction valves
  - Has remote switches to modify or capture the video image.
  - Has entry port to the instrument channel(s) is (are)
  - Fiber optic instruments have an eyepiece located at the top of the control section for direct image viewing.



The Flexible Endoscope

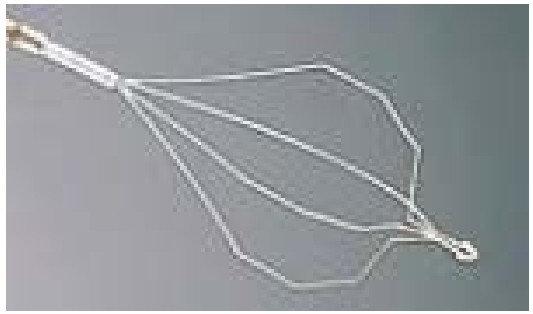
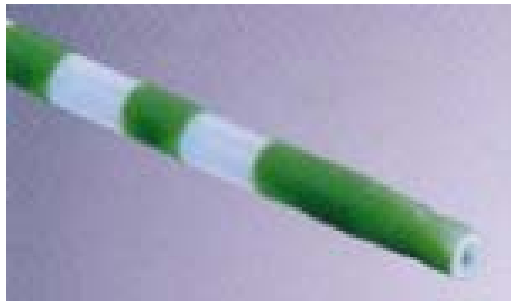
- **Insertion Section**
  - The portion of the endoscope that is inserted into the patient
  - The length, diameter, and degree of stiffness of the insertion tube vary among models.
  - The insertion tube contains
    - One or two instrument channel(s)
    - One or two light guide bundles (incoherent fiber optic)
    - An air channel, a water channel
    - Either an image guide bundle or a CCD chip with wire
    - Connections, and angulation wires.

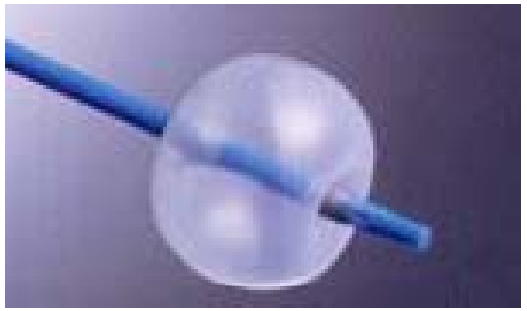




The Flexible Endoscope

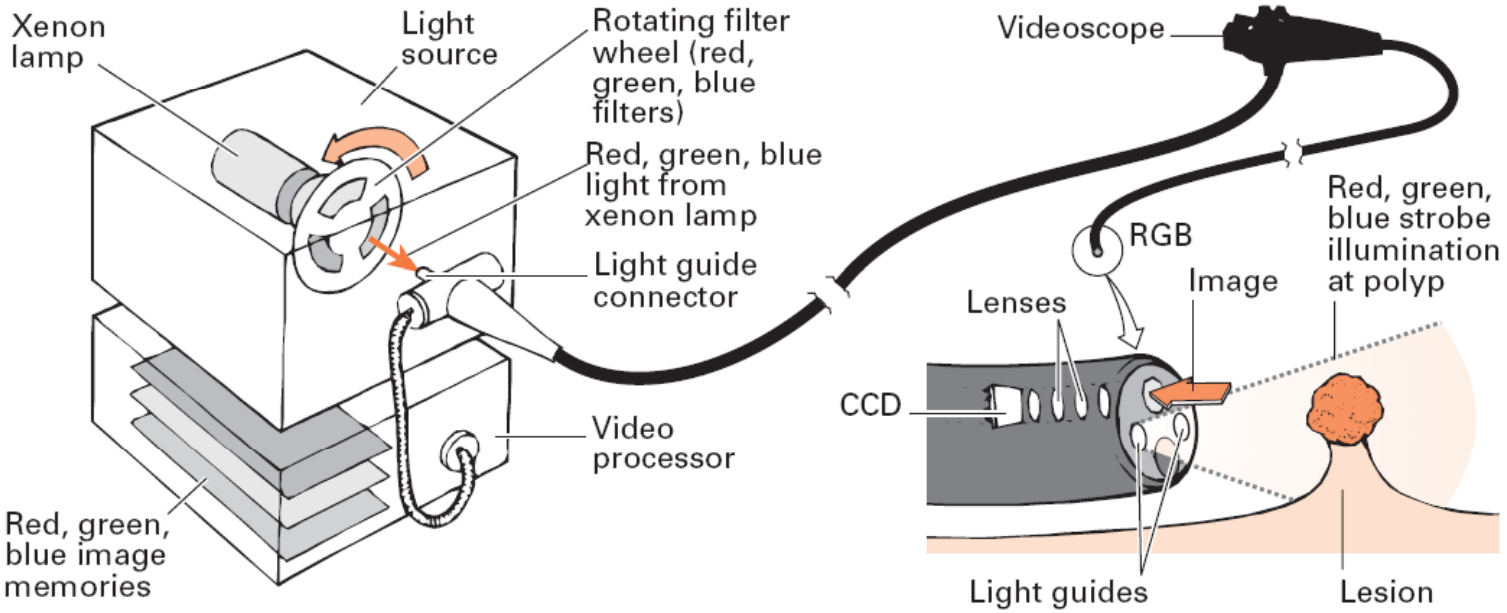
- **Endoscopic Accessories**
  - Biopsy forceps
  - Graspers
  - Baskets
  - Injectors
  - Dilators
  - Knives
  - HF endo-therapy accessories
  - . . . too many types of accessories.



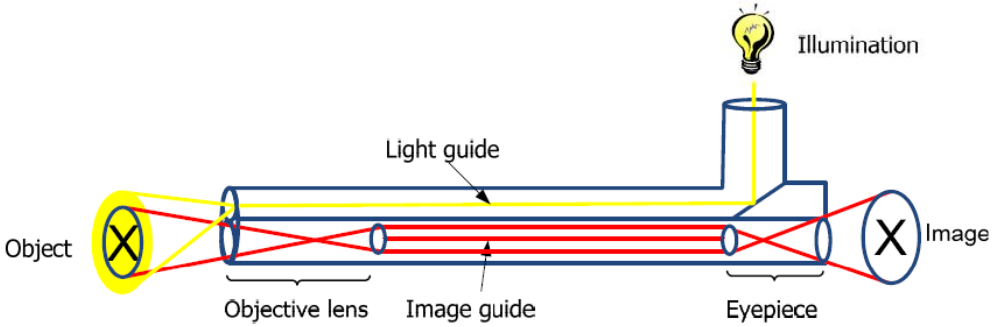

The Flexible Endoscope

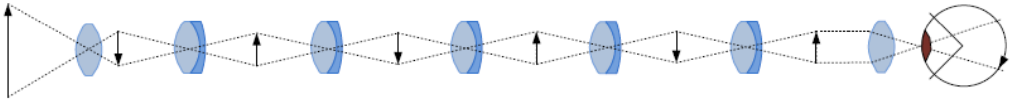
- **Connector section**
  - A light guide,
  - An air-pipe
  - Electrical contacts compatible with the processor/light source.
  - Side connectors for a water container, suction, CO2, insertion tube venting
  - An S (safety)-cord connecting mount, which grounds the endoscope, reducing the electrical shock hazard to the operator.

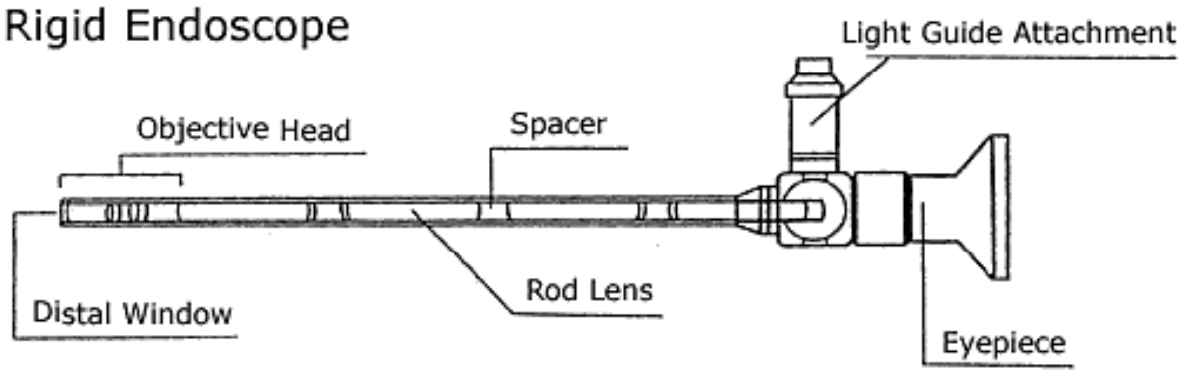


The Rigid Endoscope

- **A lens system transmitting the image to the viewer**
  - Typically a relay lens system
  - Rod lenses provide for better image quality and light efficiency
- **Different diameters and viewing angles**

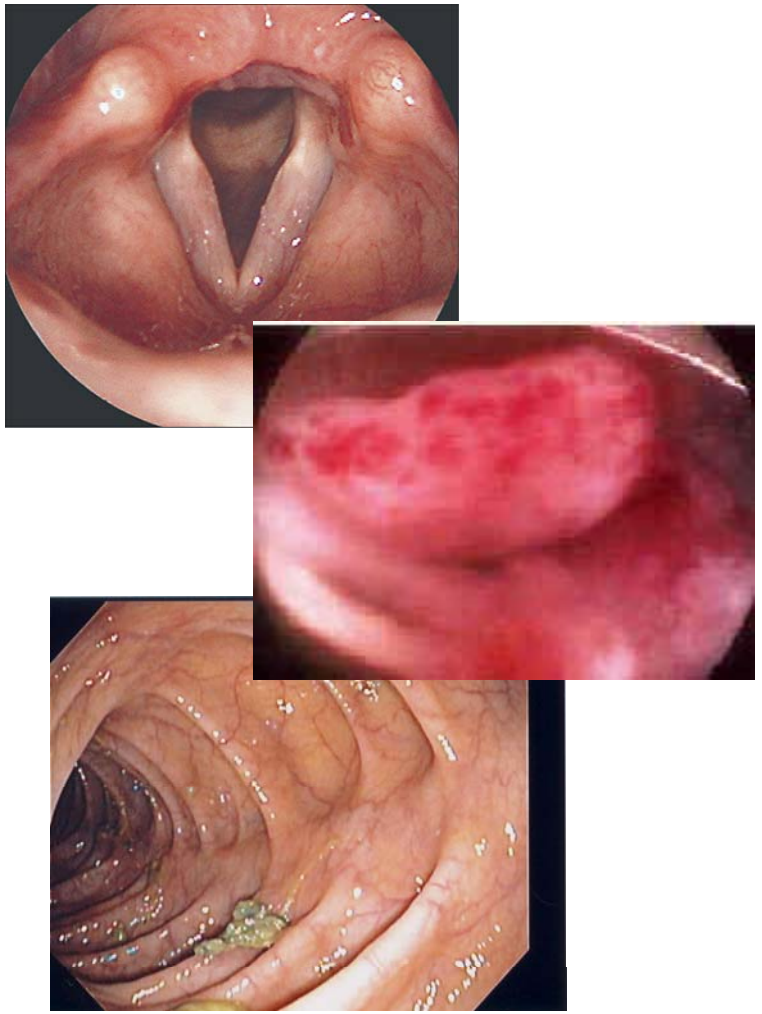




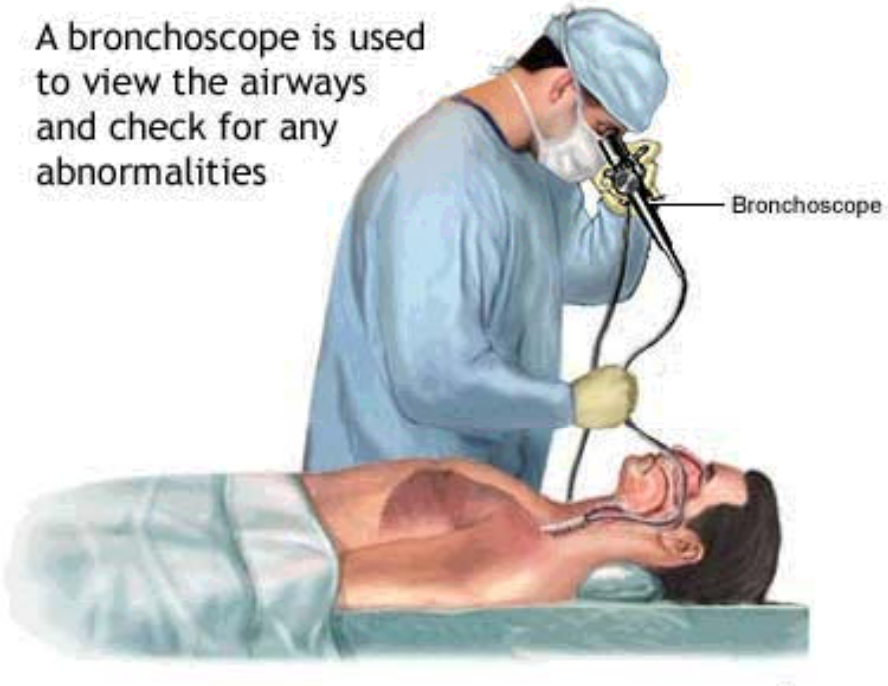


Flexible Endoscopy

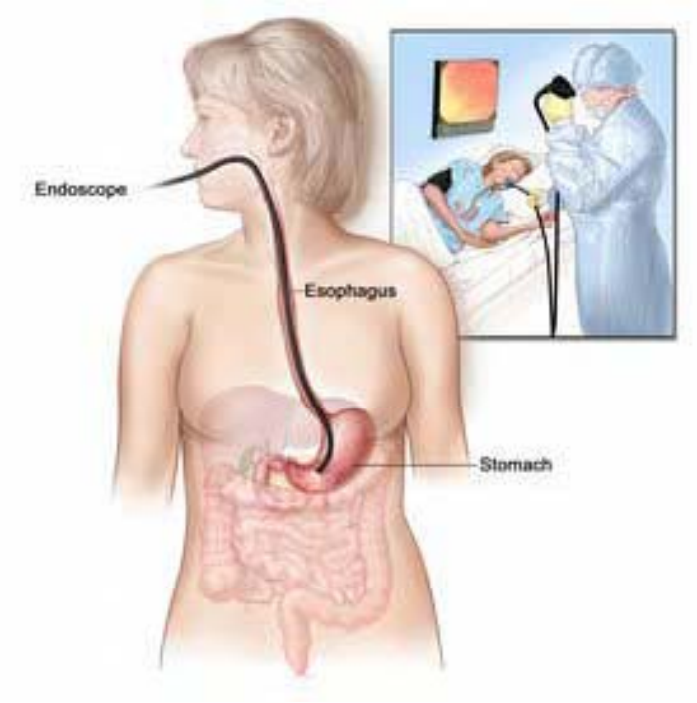
- **Depending on the body part, each type of endoscopy has its own special term, such as**
  - laryngoscopy (vocal cords)
  - bronchoscopy (lungs)
  - colonoscopy (colon)
  - Esophagoscopy (esophagus)
  - gastroscopy (Stomach)
  - Hysteroscopy (uterus)
  - etc

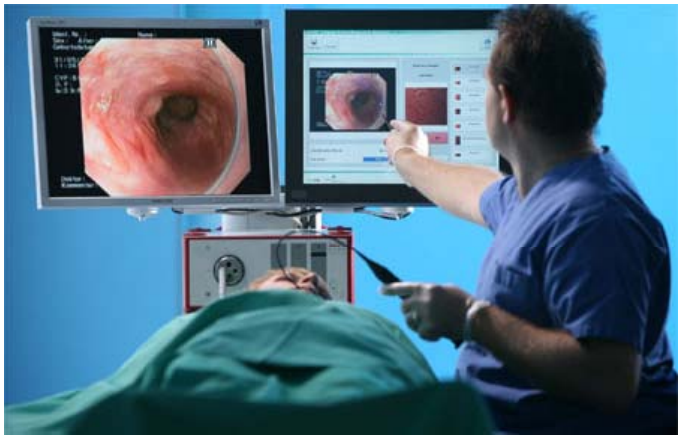


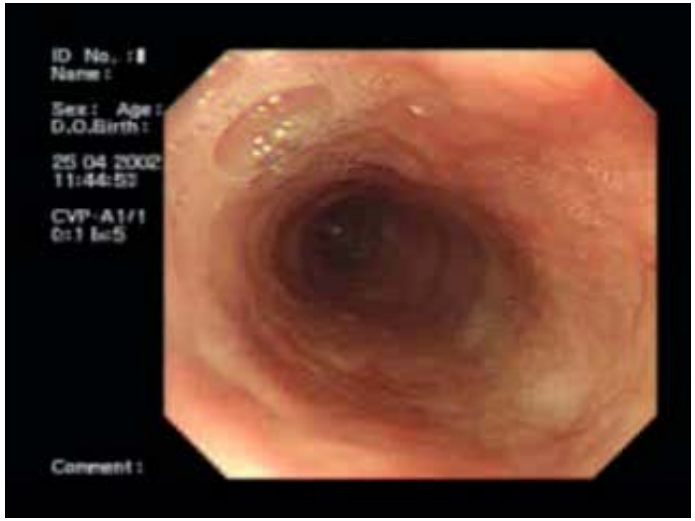
Bronchoscopy



Esophagoscopy

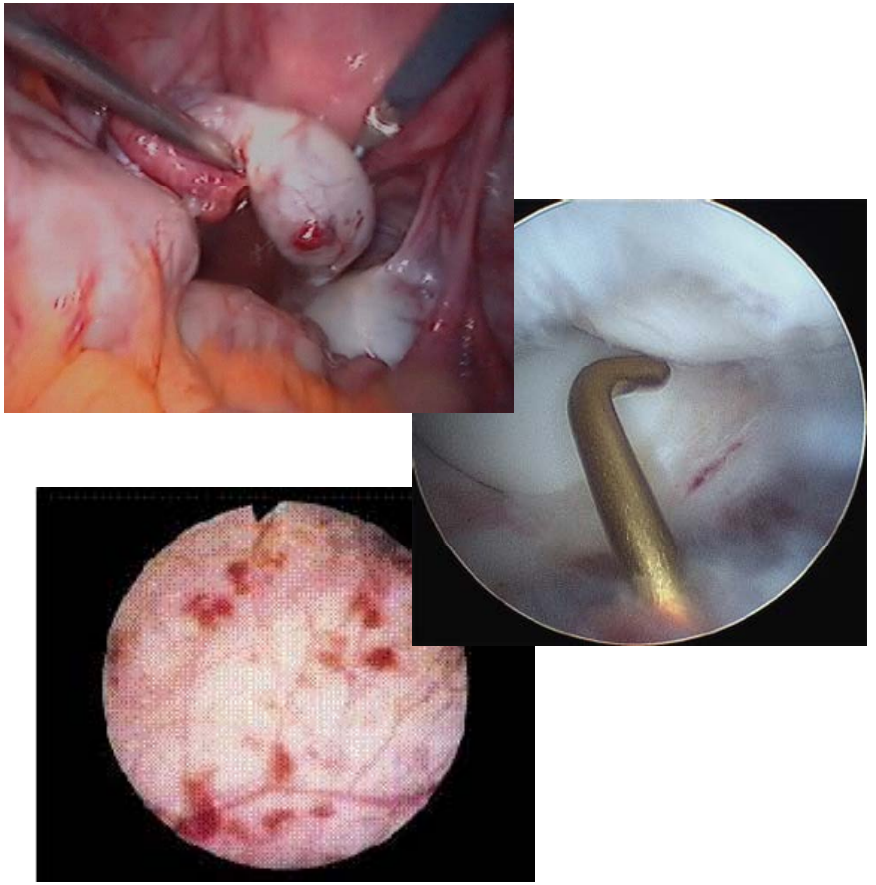




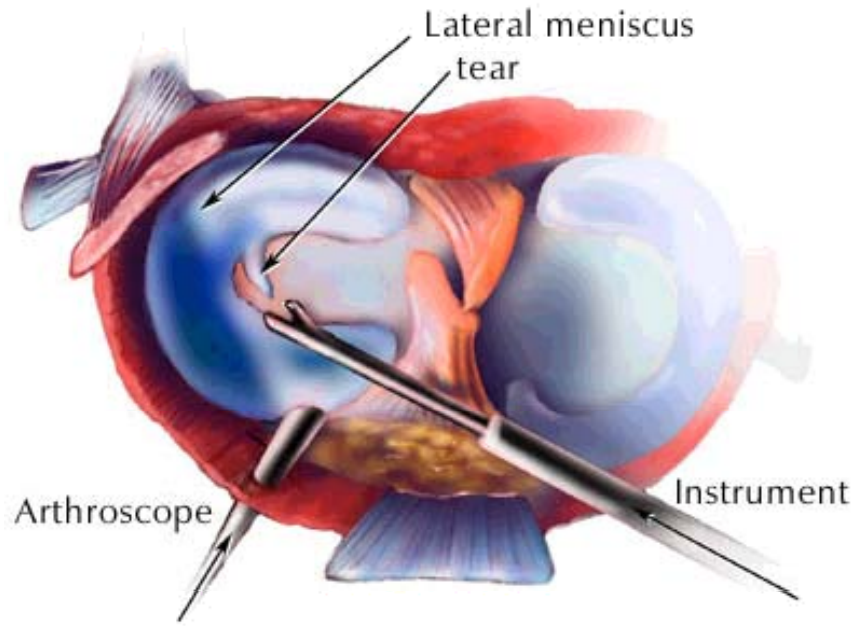


Surgical or Rigid Endoscopy

- Laparoscopy
- Arthroscopy
- Endo-Urology
- Gynecology
- E.N.T-applications
- Proctoscopy
- And many other surgical applications (gastrectomy,neurosurgery, …etc) .

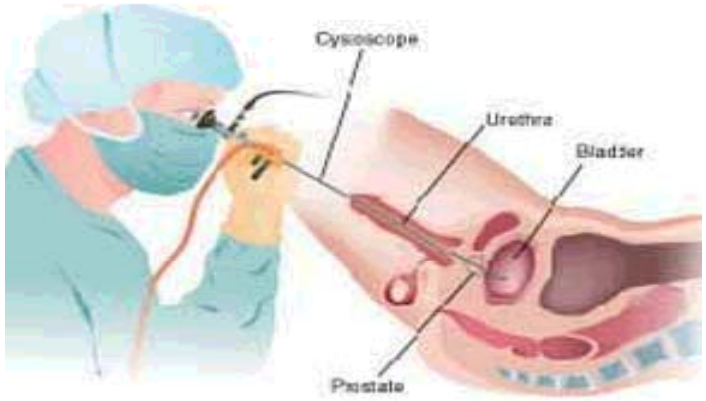


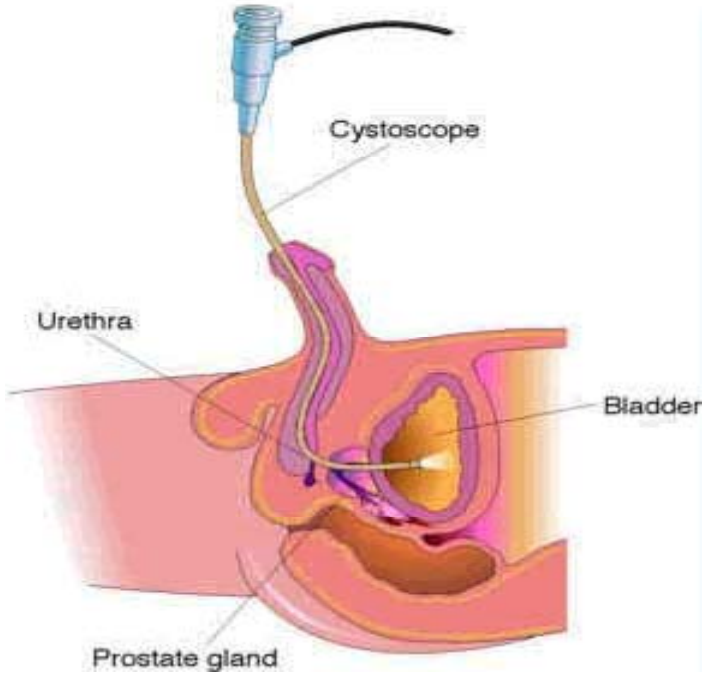
Arthroscopy

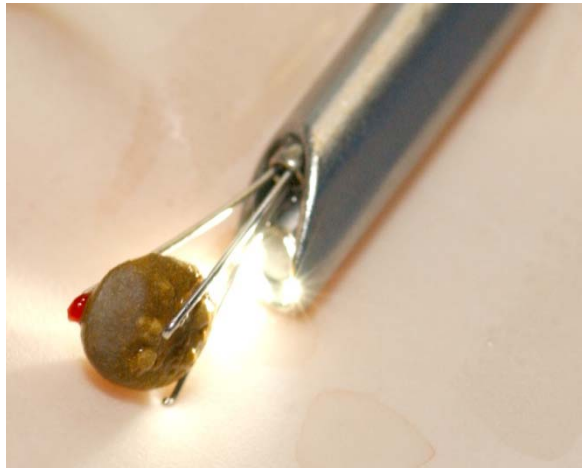


Arthroscopy can be used to repair a tear of the lateral meniscus of the knee. The arthroscope allows the surgeon to see and repair the tear inside the knee joint.

Urethrocytoscopy

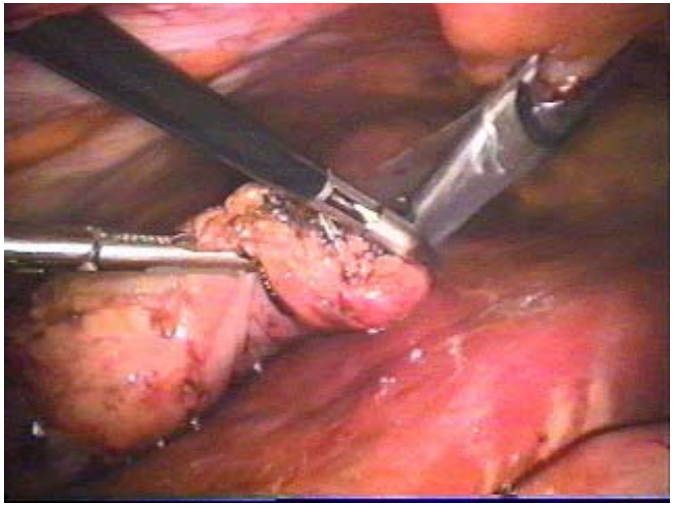






Laparoscopic Surgery

- **Laparoscopy is minimal access surgery**
  - Accomplish surgical therapeutic goals with minimal somatic and psychological trauma.
- **A rigid endoscope is introduced through a sleeve into the peritoneal cavity.**
- **The abdomen inflated with carbon dioxide**
- **Further sleeves or ports are inserted to enable instrument access and their use for dissection.**



Laparoscopic Surgery

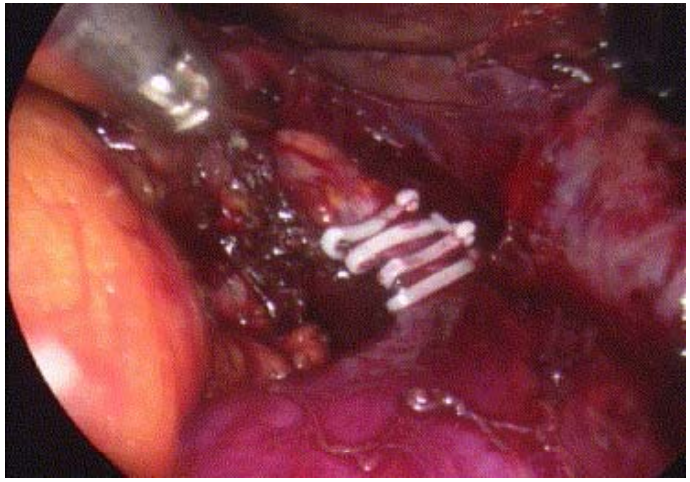
- **Examples**
  - Laparoscopic cholecystectomy has become the standard of management of uncomplicated gallstone disease.
- **With improved instruments and more experience it is likely that other advanced procedures, previously regarded as controversial, will also become fully accepted**
  - E.g. laparoscopic colectomies for malignancy,

Benefits of Laparoscopic Surgery

- Smaller incision
- Improved cosmetics
- Reduced possibility of infection
- Reduced post op pain
- Reduced blood loss
- Return home quicker
- Return to work quicker!

Limitations of Laparoscopic Surgery

- Reliance on remote vision and operating
- Loss of tactile feedback
- Dependence on hand–eye coordination
- Difficulty with haemostasis
- Extraction of large specimens
- Reliance on new techniques

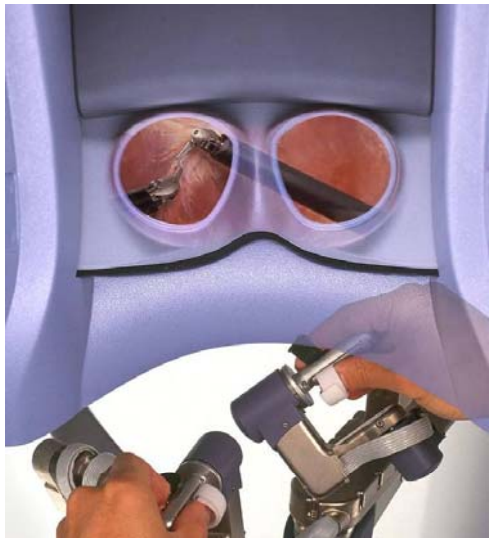


Da Vinci Surgical System

- **Not really a robot!**
  - Master-slave system – the surgeon directly initiates all the movements of the robotic instruments in real time
- **The prototype was developed by Stanford Research Institute in 1980s, funded by US Army, to perform battlefield surgery remotely by a surgeon in the safe rear**
- **FDA approved in human operations in 2000**

Da Vinci Surgical System

- **Imaging**
  - Double lenses laparoscope
  - 3D, high definition, binocular view
  - 10-15X magnification
- **Dexterity**
  - Endowrist instruments have 6 degrees of freedom
  - Filtering off hand tremor
  - Scaling down movements 1-5X

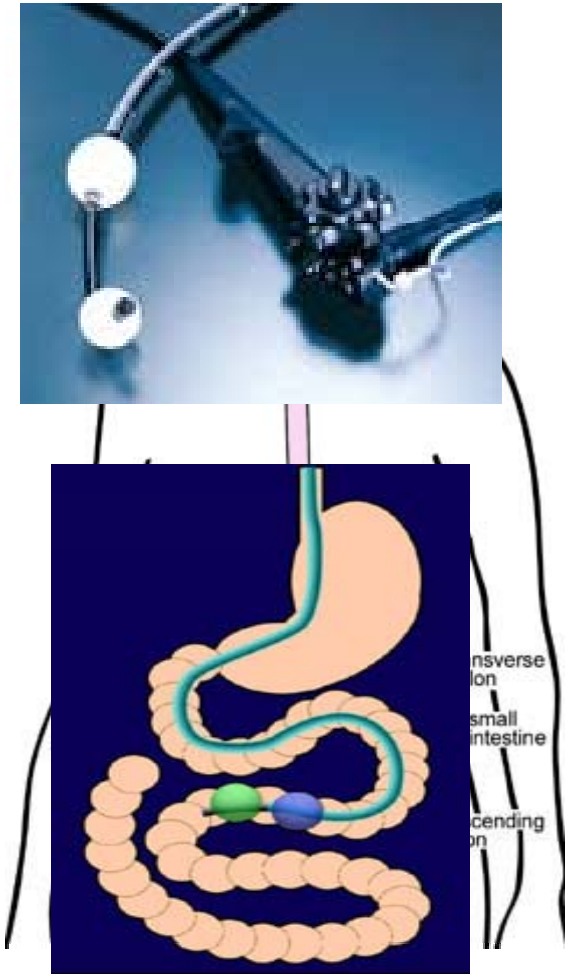


Da Vinci Surgical System

- **DaVinci Offers**
  - Improved dexterity
  - Better control
  - Better precision
  - Improved ergonomics – decreased fatigue and strain
- **Advantages**
  - Reduced hospital stay
  - More high risk patients can be treated
  - Less staff required
- **Limitations**
  - Cost of equipment $1 million
  - Steep learning curve for surgeons
  - Doctors training on device felt hindered by lack of ability to feel the tissue they're working on
  - Surgery with this system takes 40-50 minutes longer than standard procedure

Limitation of Fiberoptic Endoscopy

- **Double Balloon (Push-and-Pull) Endoscopy**
  - Fiberoptic method to visual the entire small bowel
  - Two balloons are inflated and deflated in sequence to move the endoscope through the bowel
- **Advantages**
  - Complete visualization of the entire small bowel to the terminal ileum
  - Can do therapeutic interventions
  - Allows for sampling/biopsying of small bowel mucosa
  - Allows for resection of polyps
  - Placement of stents or dilation of small bowel strictures
- **Disadvantages**
  - Technically difficult procedure
  - Very time consuming (Procedure can take > 3 hours)
  - Patient may need to be admitted to the hospital
  - Higher risk of small bowel perforation
  - Case reports of pancreatitis and intestinal necrosis
  - Reported incidents of aspiration and pneumonia



Capsule Endoscopy

- **Capsule endoscopy was first used in humans in 1999.**
- **First publication on capsule endoscopy was published in Nature in 2000:**
  - Iddan G, Meron G, Glukhovsky A, Swain P. Wireless capsule Endoscopy. Nature. 2000; 405:417.
- **Two major companies have capsule endoscopy products.**
  - Given Imaging has the PillCam
  - Olympus has the EndoCapsule
- **The latest pill camera**
  - Sized at 26x11 mm
  - Capable of transmitting 50,000 color images during its traversal through the digestive system of patient.

Inside a Capsule Camera

1.Optical Dome

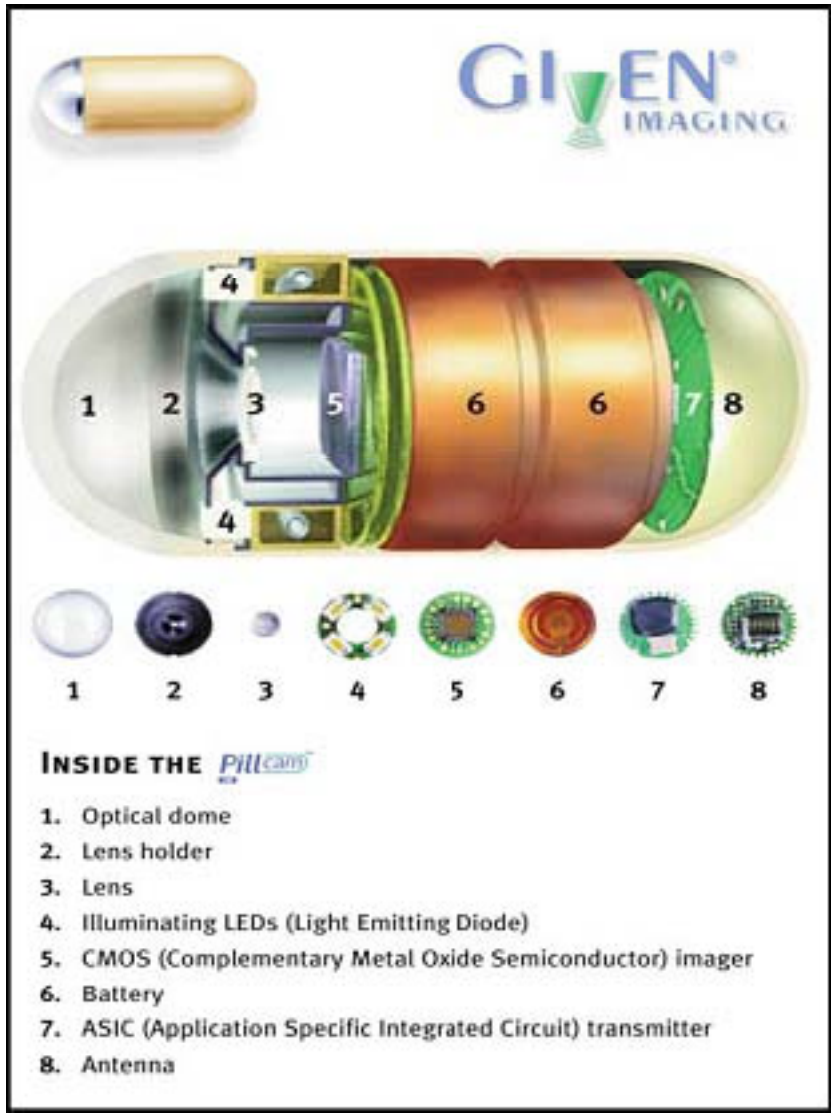
- This shape results in easy orientation of the capsule axis along the central axis of small intestine and so helps propel the capsule forward easily.
- The Optical Dome contains the Light Receiving Window .

2.Lens Holder

- The Lens Holder is that part of the capsule which accommodates the lens. The lens is tightly fixed to the holder so that it doesn't get dislocated anytime.

3.Lens

- The Lens is an integral component of the capsule.
- It is arranged behind the Light Receiving Window.



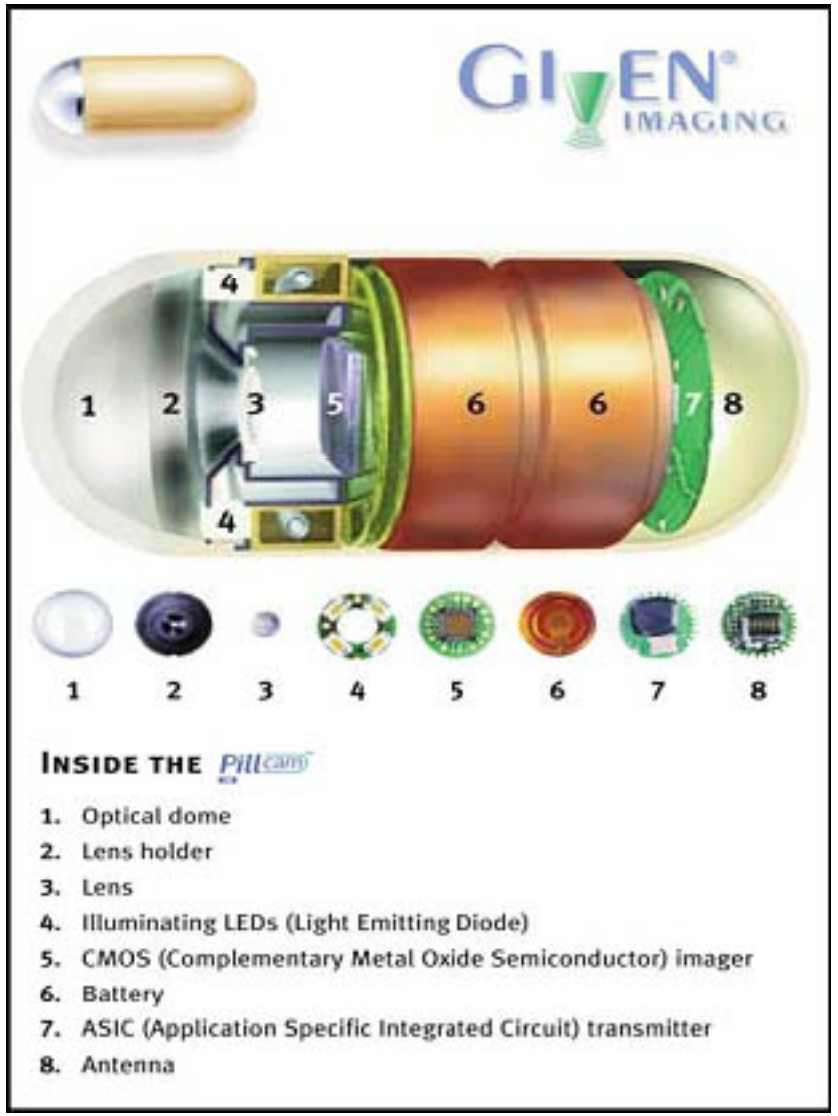
Inside a Capsule Camera

4.Illuminating LED's

- Around the Lens & CMOS Image Sensor, four LED's (Light Emitting Diodes) are present. These plural lighting devices are arranged in donut shape.

5.CMOS Image Sensor

- CMOS (Complementary Metal Oxide Semiconductor) Image Sensor is the most important part of the capsule. It is highly sensitive and produces very high quality images.
- It has 140º field of view and can detect objects as small as possible.



Inside a Capsule Camera

6.Battery

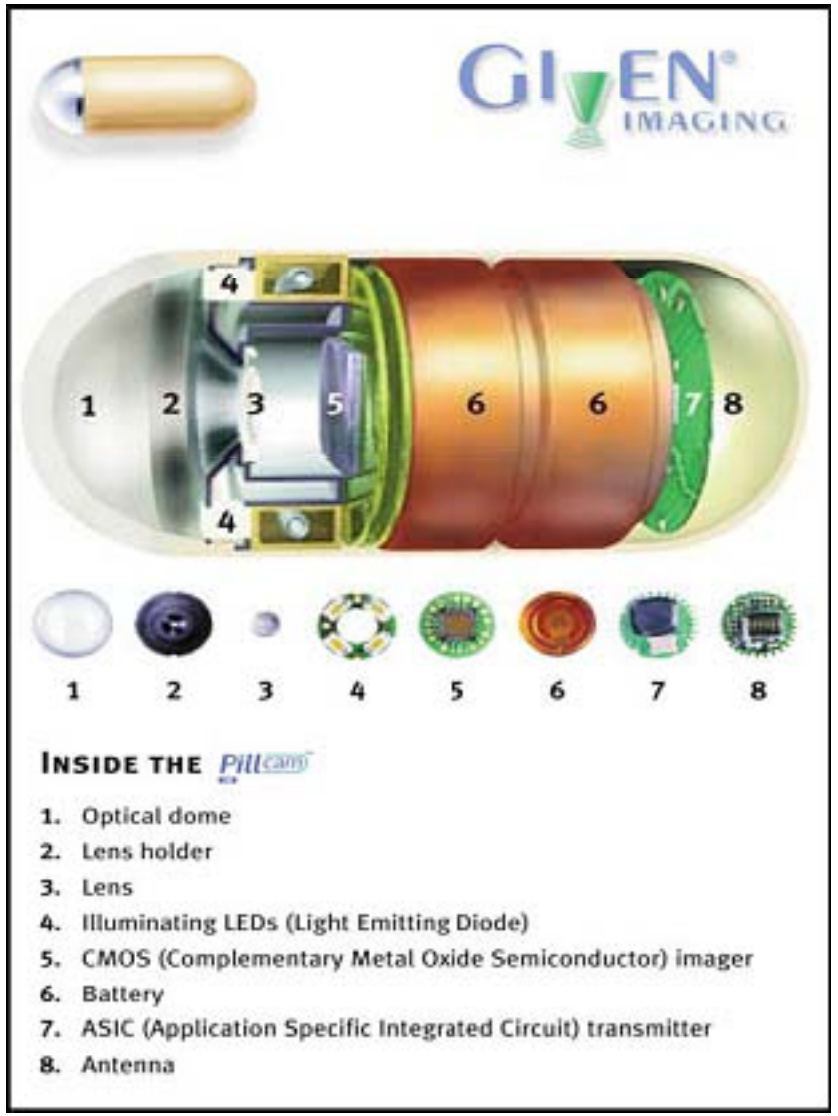
- Two batteries
- Silver Oxide primary batteries are used (Zinc/Alkaline Electrolyte/Silver Oxide). Such a battery has a even discharge voltage, disposable and doesn't cause harm to the body.

7.ASIC Transmitter

- The ASIC (Application Specific Integrated Circuit) Transmitter is arranged behind the Batteries as shown. Two Transmitting Electrodes are connected to the outlines of the ASIC Transmitter.
- These electrodes are electrically isolated from each other.

8.Antennae

- As shown, the Antennae is arranged at the end of the capsule. It is enclosed in a dome shaped chamber.

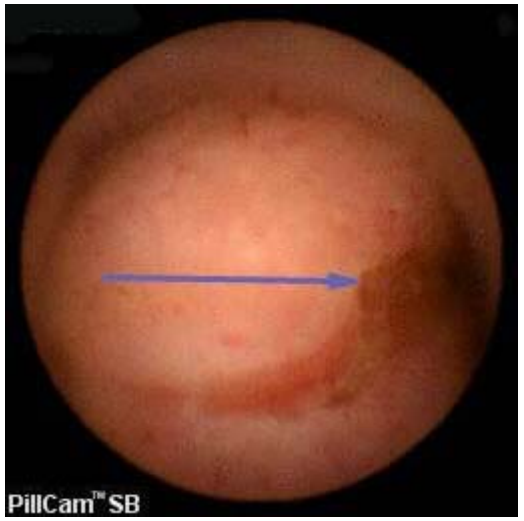


How does Capsule Endoscopy Work?

- Capsule is swallowed by the patient like a conventional pill.
- It takes images as it is propelled forward by peristalsis.
- A wireless recorder, worn on a belt, receives the images transmitted by the pill.
- A computer workstation processes the data and produces a continuous still images.

Advantages of Capsule Endoscopy

- **Uses**
  - Crohn's Disease.
  - Malabsorption Disorders.
  - Tumors of the small intestine & Vascular Disorders.
  - Ulcerative Colitis
  - Medication Related To Small Bowel Injury.
- **Advantages**
  - Painless, no side affects or complications.
  - Miniature size, so can move easily through the digestive system.
  - Accurate, precise and effective.
  - Images taken are of high quality are sent almost instantaneously to the data recorder for storage.
  - Made of bio-compatible material, doesn't cause any harm to the body.



Limitations of Capsule Endoscopy

- **Anatomical Limitations**
  - Slow Gastric/Intestinal Motility.
  - Narrowing or obstruction
  - Potentially obstructed views
  - Morbidly obese patients
- **Technical limitations**
  - Poorer quality of images as compared to Fiberoptic scopes
  - The position of the capsule can not be accurately controlled
  - Interpretation of results are very observer dependent
  - Findings may be of unknown significance or relevance.
  - Inability to biopsy or treat any pathology seen.
- **Overcomes**
  - Smaller devices
  - Bi-directional telemetry camera?